VI. Claims

What is claimed is:

1. A multi-axis input transducer apparatus comprising:

- an at least quinary input element capable of input with respect to at least five frames of reference,
- a reflective element responsive to radiation from a source capable of emitting radiation eventually incident upon said reflective element; and
- at least one reflected radiation detector responsive to radiation from said reflective element.

2. The multi-axis input transducer apparatus as described in claim 1 wherein said at least quinary input element comprises an at least sextet input element capable of input with respect to at least six frames of reference.

3. The multi-axis input transducer apparatus as described in claim 2 wherein said at least six frames of reference comprise at least three translational frames of reference and at least three rotational frames of reference.

4. The multi-axis input transducer apparatus as described in claim 3 wherein said at least three translational frames of reference and said at least three rotational frames of reference are characterized by three mutually orthogonal axes.

5. The multi-axis input transducer apparatus as described in claim 1 wherein said source of radiation comprises a source of electromagnetic radiation.

6. The multi-axis input transducer apparatus as described in claim 5 wherein said source of electromagnetic radiation comprises a source of visible light.

7. The multi-axis input transducer apparatus as described in claim 1 wherein said at least five frames of reference comprises at least three translational frames of reference.

8. The multi-axis input transducer apparatus as described in claim 1 wherein said at least five frames of reference comprises at least three rotational frames.

9. The multi-axis input transducer apparatus as described in claim 1 wherein said at least five frames of reference comprise three translational frames of reference and two rotational frames of reference.

10. The multi-axis input transducer apparatus as described in claim 1 wherein said at least five frames of reference comprise at least five axes.

11. The multi-axis input transducer apparatus as described in claim 10 wherein said at least five axes comprise three mutually orthogonal axes.

12. The multi-axis input transducer apparatus as described in claim 1 further comprising a comparatively non-reflective element upon which radiation from said source is eventually incident.

13. The multi-axis input transducer apparatus as described in claim 12 wherein said comparatively non-reflective element forms at least one abrupt border with said reflective element where there is an abrupt change from reflective to comparatively non-reflective.

14. The multi-axis input transducer apparatus as described in claim 13 wherein said at least one abrupt border comprises at least two abrupt borders.

15. The multi-axis input transducer apparatus as described in claim 14 wherein said at least two abrupt borders comprises at least two substantially orthogonal abrupt borders.

16. The multi-axis input transducer apparatus as described in claim 14 or 15 wherein said reflect element and said comparatively non-reflective element abut to form a triangulated pattern.

17. The multi-axis input transducer apparatus as described in claim 13 wherein said at least one abrupt border comprises at least two abrupt borders.

18. The multi-axis input transducer apparatus as described in claim 17 wherein said at least two abrupt borders zig zag.

19. The multi-axis input transducer apparatus as described in claim 1 wherein said reflective element is established extra-radially of said source.

20. The multi-axis input transducer apparatus as described in claim 1 wherein said at least one reflected radiation detector is established intra-radially of said reflective element.

21. The multi-axis input transducer apparatus as described in claim 12 or 20 wherein said reflective element and said comparatively non-reflective element is established extra-radially of said source.

22. The multi-axis input transducer apparatus as described in claim 12 or 20 wherein said reflective element and said comparatively non-reflective element are established extra-radially of said at least one reflected radiation detector.

23. The multi-axis input transducer apparatus as described in claim 1 wherein said at least quinary input element comprises a joystick.

24. The multi-axis input transducer apparatus as described in claim 1 wherein said reflective element comprises an annular reflective element.

25. The multi-axis input transducer apparatus as described in claim 12 wherein said reflective element and said comparatively non-reflective element are annularly established.

26. The multi-axis input transducer apparatus as described in claim 21 wherein said reflective element and said comparatively non-reflective element are annularly established.

27. The multi-axis input transducer apparatus as described in claim 1 wherein said at least one reflective radiation detector comprises at least six reflected radiation detectors.

28. The multi-axis input transducer apparatus as described in claim 1 wherein said at least one reflected radiation detector is capable of emitting a signal relative to radiation from said reflective element.

29. The multi-axis input transducer apparatus as described in claim 28 wherein said signal relative to radiation from said reflective element comprises an electrical signal.

30. The multi-axis input transducer apparatus as described in claim 28 wherein said signal relative to radiation from said reflective element comprises an optical signal.

31. A joystick comprising a radiation source, a reflector, and reflected radiation sensor, at least one of which is movable with respect to at least one other of said three elements in at least three degrees of freedom, wherein said radiation source projects radiation eventually incident upon said reflector, said reflector reflects a varying reflected optical signal to said reflected radiation sensor in a manner which varies in at least three degrees of freedom, and said reflected radiation sensor senses at least a portion of said varying reflected optical signal.

32. A joystick as in claim 31 wherein said source of radiation comprises a visible light source of radiation.

33. A joystick as in claim 31 wherein said source of radiation comprises a infrared source of radiation.

34. A joystick as in claim 31 wherein said source of radiation comprises an ultraviolet light source of radiation.

35. The joystick of claim 31 wherein the returned optical signal is detected as an image incident on an array of image sensing elements.

36. The joystick of claim 35 wherein the array of the image sensing elements comprises a CCD camera.

37. The joystick of claim 35 or 36 further comprising a wide angle lens.

38. The joystick of claim 31 wherein said reflected radiation sensor comprises a photo detector and the radiation source comprises time sequenced light emitters.

39. The joystick of claim 31 wherein the reflected radiation sensor comprises multiple detectors acting in parallel in conjunction with said radiation source, wherein said radiation source comprises time sequenced light emitters.

40. The joystick of claim 31 wherein the reflected radiation sensor comprises time sequenced light detectors.

41. The joystick of claim 31 wherein said reflected radiation sensor and said radiation source are established as part of a monolithic device.

42. The joystick of claim 31 wherein said varying reflected optical signal is transduced by a monolithic device.

43. The joystick of claim 41 wherein said monolithic device includes embedded non-optical electronic components.

44. The joystick of claim 43 wherein embedded non-optical electronic components include a microprocessor.

45. The joystick of claim 41 wherein said monolithic device comprises a generally planar substrate supporting one or more optical emitters and one or more optical detectors embedded in a light transmissive medium.

46. The joystick of claim 41 wherein said monolithic device comprising a generally planar substrate supporting one or more optical emitters, one or more optical detectors and non-optical electronic components embedded in a light conductive medium.

47. The joystick of claim 31 wherein structured light is projected onto the reflector.

48. The joystick of claim 31 wherein said reflector comprises at least one patterned reflective element.

49. The joystick of claim 31 wherein the reflector comprises multiple reflective facets.

50. The joystick of claim 31 wherein the reflector includes at least one retro-reflective element.

51. The joystick of claim 31 wherein the radiation source, the reflector, and the reflected radiation sensor are protected by a flexible diaphragm.

52. The joystick of claim 31 including elastic position restoring element.

53. The joystick of claim 52 wherein the elastic position restoring element comprises a spring.

54. The joystick of claim 52 wherein the elastic position restoring element comprises a spring fixed at a first end to a first movable element and fixed at a second end to a second movable element wherein a displacement detection element is located near a plane normal to the axis of and near the center of said spring.

55. The joystick of claim 52 wherein the elastic position restoring element comprises a spring fixed at a first end to a first movable element and fixed at a second end to a second movable element wherein the center of a joystick grip is located near a plane normal to the axis of and near the center of said spring.

56. The joystick of claim 55 wherein a center of said joystick grip is coplanar with said plane normal to the axis of said spring.

57. The joystick of claim 52 wherein the elastic position restoring element comprises a substantially planar spring.

58. The joystick of claim 52 wherein the elastic position restoring element comprises at least one spring located coaxially with the optical elements the joystick.

59. A joystick comprising at least two elements movable with respect to each other in at least three degrees of freedom wherein one or more conductive elastomeric elements are utilized to generate a position signal of at least three degrees of freedom.

60. A joystick comprising at least two elements movable with respect to each other in at least three degrees of freedom wherein one or more ionically conductive elements are utilized to generate a position signal of at least three degrees of freedom.

61. A joystick comprising at least two elements movable with respect to each other in at least three degrees of freedom wherein one or more conductive deformable liquid elements are utilized to generate a position signal of at least three degrees of freedom.

62. A joystick comprising at least two elements movable with respect to each other in at least three degrees of freedom wherein one or more conductive deformable gel elements are utilized to generate a position signal of at least three degrees of freedom.

63. A joystick comprising at least two elements movable with respect to each other in at least six degrees of freedom wherein one or more conductive elastomeric elements are utilized to generate a position signal of at least six degrees of freedom.

64. A joystick comprising at least two elements movable with respect to each other in at least six degrees of freedom wherein one or more ionically conductive elements are utilized to generate a position signal of at least six degrees of freedom.

65. A joystick comprising at least two elements movable with respect to each other in at least six degrees of freedom wherein one or more conductive deformable liquid elements are utilized to generate a position signal of at least six degrees of freedom.

66. A joystick comprising at least two elements movable with respect to each other in at least six degrees of freedom wherein one or more conductive deformable gel elements are utilized to generate a position signal of at least six degrees of freedom.

67. A joystick comprising at least two elements movable with respect to each other in at least three degrees of freedom wherein one or more conductive elastomeric elements are utilized to generate a position signal of at least three degrees of freedom.

68. A joystick comprising at least two elements movable with respect to each other in at least three degrees of freedom wherein six or more ionically conductive elements are utilized to generate a position signal of at least six degrees of freedom.

69. A joystick comprising at least two elements movable with respect to each other in at least three degrees of freedom wherein six or more conductive deformable liquid elements are utilized to generate a position signal of at least six degrees of freedom.

70. A joystick comprising at least two elements movable with respect to each other in at least six degrees of freedom wherein six or more conductive deformable gel elements are utilized to generate a position signal of at least six degrees of freedom.

71. A joystick comprising at least two elements movable with respect to each other in at least six degrees of freedom wherein six or more conductive elastomeric elements are utilized to generate a position signal of at least six degrees of freedom.

72. A joystick comprising at least two elements movable with respect to each other in at least six degrees of freedom wherein six or more ionically conductive elements are utilized to generate a position signal of at least six degrees of freedom.

73. A joystick comprising at least two elements movable with respect to each other in at least six degrees of freedom wherein six or more conductive deformable liquid elements are utilized to generate a position signal of at least six degrees of freedom.

74. A joystick comprising at least two elements movable with respect to each other in at least six degrees of freedom wherein six or more conductive deformable gel elements are utilized to generate a position signal of at least six degrees of freedom.

75. A joystick comprising at least two elements movable with respect to each other in at least 6 degrees of freedom wherein one or more conductive elastomeric elements are utilized to generate a position signal of at least 6 degrees of freedom.

76. A joystick comprising at least two elements movable with respect to each other in at least 3 degrees of freedom wherein one or more elastomeric cavities containing

conductive fluid are utilized to generate a position signal of at least 3 degrees of freedom.

77. A joystick comprising at least two elements movable with respect to each other in at least 6 degrees of freedom wherein one or more elastomeric cavities containing conductive fluid are utilized to generate a position signal of at least 6 degrees of freedom.

78. A joystick comprising at least two movable joints between a least three elements movable with respect to each other, wherein at least one of said movable joints is movable in 6 degrees of freedom.

79. The joystick of claim 78 wherein at least one element may be secured against a user's palm while another of the movable elements may be manipulated with the user's fingers.

80. The joystick of claim 78 wherein at least one movable element may be secured against the user's palm by the users ring and little fingers while another of the movable elements may be manipulated with the user's thumb, index finger and middle finger.

81. A joystick of at least 6 degrees of freedom with a grip of less than 2 inches in diameter able to be manipulated by the user's index finger, middle finger and thumb.

82. A gaming joystick with a least 6 degrees of freedom with a grip less than 6 inches in circumference wherein the transducer means is at any time during use located within an envelope defined by an imaginary extended surface of the users forearm.

83. A computer mouse movable in at least two axis which serves as a base of an attached multi-axis joystick.

84. A computer mouse able to register sliding motion relative to a supporting surface along an x axis, along a y axis, and rotation about the z axis.

85. A combination comprising the computer mouse of claim 84 and an appended multi-axis joystick.

86. A joystick movable in 6 degrees of freedom including a base portion which includes a gel pad support.

87. The joystick of claim 86 which includes mouse functionality of the joystick base portion relative to its supporting surface.

88. A joystick of 6 degrees of freedom comprising a base portion and a grip portion movable relative thereto in which the base portion is flexibly supported.

89. The joystick of claim 88 wherein the base portion is flexibly supported in a manner which limits coupling between the rotational and translational degrees of freedom.

90. The joystick of claim 88 wherein the base portion is flexibly supported in a manner which limits mechanical coupling between the rotational and translational degrees of freedom.

91. The joystick of claim 90 wherein the base portion is flexibly supported by parallel members rotatably flexible about the z axis which are in turn supported by a structure flexible in z axis translation but stiff in z axis rotation.

92. The joystick of claim 90 wherein the base portion is flexibly supported by and fixed to one end of three or more generally parallel first flexible members aligned with a first axis in a manner allowing rotational flexibility of said base portion about said first axis wherein a second end of said first flexible members is connected to two or more generally parallel second flexible members, which second flexible members are

flexible in bending along said first axis and which y aligned with a second axis generally orthogonal to said first axis and which are relatively stiff in bending along a third generally orthogonal axis.

93. The joystick of claim 88 wherein one or more movable members are sealed to one or more stationary members by flexible bellows.

94. The joystick of claim 93 wherein the flexible bellows is torsionally compliant about the z axis.

95. The joystick of claim 94 wherein portions of the flexible bellows are rotatably fixed about the z axis to both of one or more stationary elements and to one or more movable elements.

96. The joystick of claim 95 wherein a flexible diaphragm compensates for air or fluid displacement the flexible bellows.

97. The joystick of claim 95 wherein a second flexible bellows compensates for air or fluid displacement the first flexible bellows.

98. The joystick of claim 95 wherein a second flexible bellows which is mechanically coupled to each of two or more independently movable elements compensates for air or fluid displacement of a first flexible bellows.

99. A multi-axis joystick wherein motion is coupled through a first flexible bellows or diaphragm and wherein a second flexible bellows or diaphragm is mechanically coupled to each of at least two joystick elements movable with respect to each other.

100. A multi-axis joystick including means to remove from the output signal that portion of the signal attributable to gravitational or inertial forces transmitted through the user's hand.

101. A multi-axis joystick comprising:

a finger operable first portion at least quinaxially responsively connected to a second portion; and

a hand operable second portion at least uniaxially responsively connected to a third portion, each movable connection generating a signal in response to relative movement.

102. A multi-axis joystick comprising:

a finger operable first portion at least quinaxially responsively connected to a second portion; and

a hand operable second portion at least biaxially responsively connected to a third portion, each movable connection generating a signal in response to relative movement.

103. A multi-axis joystick comprising:

a finger operable first portion at least quinaxially responsively connected to a second portion; and

a hand operable second portion at least triaxially responsively connected to a third portion, each movable connection generating a signal in response to relative movement.

104. A multi-axis joystick comprising:

a finger operable first portion at least quinaxially responsively connected to a second portion; and

a hand operable second portion at least quadaxially responsively connected to a third portion, each movable connection generating a signal in response to relative movement.

105. A multi-axis joystick comprising:

a finger operable first portion at least quinaxially responsively connected to a second portion; and

a hand operable second portion at least quinaxially responsively connected to a third portion, each movable connection generating a signal in response to relative movement.

106. An at least six axis joystick, comprising:

a first portion including a magnetic flux circuit including one or more air gaps and movable relative to a second portion in six degrees of freedom;

a second portion including flux sensitive sensors positioned relative to flux gradients in a manner which generates a signal from which six degree of freedom position of the first portion relative to the second portion may be derived.

107. An at least six axis joystick, comprising:

a first portion including a magnetic flux circuit including one or more air gaps and movable relative to a second portion in six degrees of freedom;

a second portion including flux gradient sensitive sensors positioned relative to second derivative flux gradients in a manner which generates a signal from which six degree of freedom position of the first portion relative to the second portion may be derived.

108. The apparatus of claim 106 or 107 further including restoring means which does not substantially couple any of the translational axes with any of the rotational axes.

109. The apparatus of claim 108 wherein the restoring means includes at least one spring coaxial with a grip.

110. The apparatus of claim 109 including at least one coil spring.

111. An at least six-axis joystick , comprising:

a source of magnetic flux;

a first portion including a means of directing magnetic flux along at least 3 paths and a flux conducting outer portion serving as a return path for the flux;
a second portion, movable in six degrees of freedom relative to the first, including flux sensitive sensors positioned relative to flux gradients such that the sensitive axes are three-way axisymmetric and define 6 edges of a hexahedron.

112. The apparatus of claim 111 wherein the first portion includes a grip.

113. The apparatus of claim 111 wherein the flux structure is movable with respect to one or more damping circuits.

114. An at least triaxial joystick including a base portion mounted to the slave platform of a Stewart platform the primary purpose of which is to actuate said base portion.

115. An at least triaxial joystick including a base portion mounted to the slave platform of a Stewart platform the primary purpose of which is to actuate said base platform..

116. An at least triaxial joystick including a base portion mounted to the slave platform of a Stewart platform the primary purpose of which is to actuate said base platform.

117. An at least triaxial joystick including a base portion mounted to the slave platform of a Stewart platform the primary purpose of which is to actuate said base platform.

118. The apparatus of claim 114, 115, 116, or 117 wherein said Stewart platform provides force feedback.

119. The apparatus of claim 114, 115, 116, or 117 wherein said Stewart platform provides position feedback.

120. The apparatus of claim 114, 115, 116, or 117 wherein said Stewart platform provides velocity feedback.